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TECHNICAL NOTE

Bureau of Land Management U.S. DEPARTMENT OF THE INTERIOR

HABITAT MANAGEMENT SERIES FOR UNIQUE OR ENDANGERED SPECIES

by Carol Snow, Research Biologist
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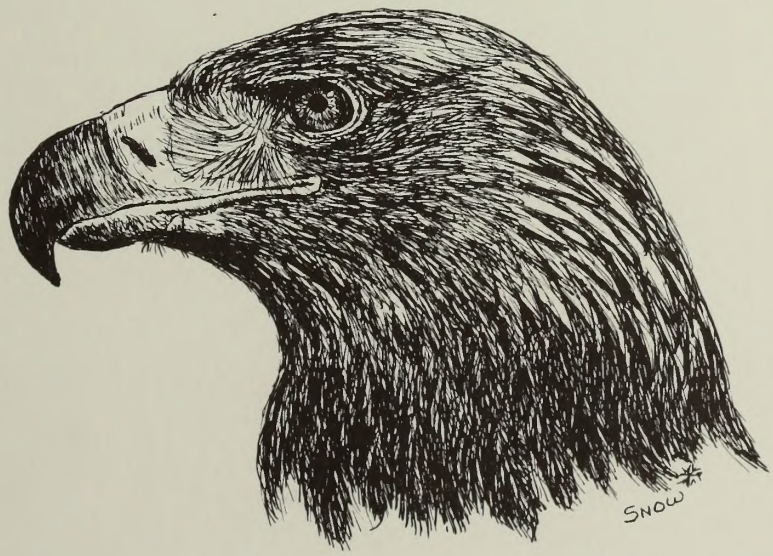
Report No. 7

Golden Eagle
Aquila chrysaetos



FOREWORD

This Technical Note series on wildlife is designed to provide a literature review and summary of current knowledge pertaining to endangered and other wildlife species occurring on public lands. We in the Bureau of Land Management have recognized the need for basic wildlife information in order to do an effective job in land-use planning. Sound planning must identify the negative aspects as well as the positive benefits of any proposed land management decision or program. It is our hope, too, that this series will also prove useful to others--be they land managers, students, researchers or interested citizens.

Frank Gregg

Director
Bureau of Land Management
Department of the Interior

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Introduction

The objective of this report is to provide BLM personnel with the latest and most up-to-date information on rare or endangered species occurring on the public domain. This will provide a tool for improved understanding of the interrelationships between the species and its environment and encourage an end product of enlightened land management which will fully consider the species' welfare in all management decisions.

1. Species Description

The golden eagle is widely distributed throughout the northern hemisphere. Eight races have been described, but only Aquila chrysaetos canadensis is found in North America. In medieval Europe, the golden eagle was flown only by kings. In many North American Indian cultures, the golden eagle is the Thunderbird, who is variously credited with the creation of the world, is a messenger of the gods, or is the Great Spirit himself. To this day eagles and eagle feathers are highly valued by many Indian tribes and are important parts of many ceremonies (Bent, 1937; Grossman and Hamlet, 1964). Feathers which are collected from accidentally killed eagles or confiscated by federal agents are often given to Indians for religious and ceremonial purposes.

Common vernacular names for the golden eagle include brown eagle, calumet eagle, ring-tailed eagle, black eagle, mountain eagle, royal eagle, war eagle, dark eagle, and black Mexican eagle. The wing span may extend from six to seven and one-half feet. The weight of mature adults varies from eight to over twelve pounds. Females are larger than males (Jollie, 1943; Kalmbach et al, 1964; Brown and Amadon, 1968).

Newly hatched eaglets are covered with short, thick, dirty-white down which is replaced with a longer, thicker pure white down. As the black feathers of the juvenile plumage begin to replace the down along certain feather tracts, there is a characteristic "black and white" phase which is apparent at about six to seven weeks of age (Murphy, 1973b). At eight weeks of age, eaglets are fully feathered. They are ready to fledge at an average age of ten weeks (Bent, 1937).

A newly fledged golden eagle has a very distinctive plumage. It is considerably darker than the adult and is blackish-brown in appearance. The crown and hackles are darker and duller. The basal one third of the feathers on the back and the basal half of the breast feathers are white. There is a broad terminal band of brownish black on the tail feathers which covers about one fourth of the central rectrices and graduates

up to approximately one half of the outer feathers. The remaining portion of the tail feathers is white. The long wing feathers are blackish with much white near the bases of the inner primaries and all the secondaries. This pattern forms a conspicuous white patch at the carpal joint of the wing which is called a "wrist patch" or a "mirror" (Bent, 1937; Brown and Amadon, 1968). This "mirror" is also visible from above (Kochert, personal communication; Nelson, personal communication). Newly-fledged eaglets are as large and as heavy as or heavier than adults (Murphy, 1973b). See Figure 2.

Adult plumage is attained over a period of three to four years and involves a gradual reduction of the amount of white at the base of the feathers. During the second year, the tail feathers have dark brown tips and are mottled with grayish brown about halfway up the vane. The middle two rectrices are completely mottled (Kochert, 1973c). At three years of age a golden eagle may still have white patches at the bases of some of its tail feathers and in some of the body plumage. The white areas in the wings gradually disappear (Bent, 1937; Brown and Amadon, 1968; Grossman and Hamlet, 1964; Jollie, 1943, 1947).

The golden eagle is named for the lanceolate feathers on the crown of the head and the nape of its neck which are tipped and edged with a tawny or golden-buff color. These hackles produce a golden cast against the otherwise sepia to dark brown plumage. The tail of the adult is more or less indistinctly and irregularly barred or spotted with dark gray or brown and has broad blackish tips. The wing feathers are brownish-black with varying amounts of white and gray mottling forming indistinct basal bands. There is little or no white in the body feathers. The feathering on the tarsi is slightly paler than on the rest of the body, and the underside tends to be paler than the upper side (Brown and Amadon, 1968; Grossman and Hamlet, 1964; Jollie, 1947; Bent, 1937). See Figure 2. Jollie (1947) gives very detailed descriptions of plumage changes in the golden eagle. Some observers have described plumages for juvenile, immature and adult birds. In this report only the terms juvenile and adult are used, with juvenile referring to all birds that are not yet in adult plumage.

Field identification may be difficult in areas where juvenile bald eagles (Haliaeetus leucocephalus) and turkey vultures (Cathartes aura) are also found. Golden eagles have fully feathered tarsi, whereas bald eagles and turkey vultures do not, but this characteristic is useful for identification only at close range. Juvenile golden eagles are usually distinguishable from adults by the large white tail base and the white wing patches. At close range adult golden eagles can be identified by the golden hackles which are also visible through good binoculars.

At a distance, eagles and vultures may appear similar, but flight patterns are different. The turkey vulture holds its wings in a dihedral and tends to soar more frequently than the golden eagle, with a somewhat rocking motion. The golden eagle's wings are held nearly horizontal when it is soaring.

The coverts on the undersurfaces of the wings of the turkey vulture appear very dark, while the undersurfaces of the primaries and secondaries appear much lighter and gray-toned. It also has a small head and long narrow tail compared to the golden eagle. It does not have white on any part of its body, as does the juvenile golden eagle. See Figure 1.

Distinctions between juvenile bald eagles and golden eagles are more nebulous. Juvenile bald eagles have variably marked gray-mottled or white-mottled tail feathers which are gradually replaced with white tail feathers. The underwing coverts are mottled with white, but they do not form white wing patches. Another useful field characteristic to distinguish juvenile bald eagles from golden eagles is the strong contrast between the brownish plumage of the breast and abdomen and the gray-mottled appearance of the underwing coverts on the bald eagle (Murphy, 1973b). Adult golden eagles have dark underwing coverts and a dark-tipped tail marked with irregular brown bars at the base. See Figure 2.

Both adult and juvenile golden eagles have brown eyes, as does the juvenile bald eagle up to the age of four. Golden eagles have black beaks, yellow ceres, yellow toes and black claws. Juvenile bald eagles tend to have brownish beaks and grayish-yellow ceres, although the beaks of first-year bald eagles may be grayish black (Jollie, 1943; Bent, 1937; Brown and Amadon, 1968; Grossman and Hamlet, 1964; Sprunt, 1973; Robards, 1973).

2. Distribution, Present and Former

Aquila chrysaetos canadensis is found from northern Alaska in the Brooks Range, British Columbia, Mackenzie, northern Saskatchewan, northern Manitoba and Quebec, and the Gaspe Peninsula south to northern Baja California, Sonora, Sinaloa, Durango, Guanajuato, Nuevo Leon, west Texas (Brewster County), western Oklahoma, western Nebraska, western South Dakota, eastern Montana, northern Ontario across to New York, northern New Hampshire and Maine (A.O.U., 1957).

Golden eagles also bred in the Appalachian Mountains in the eastern United States. There are still reports received of an occasional pair of golden eagles breeding in this mountain range (Spofford, 1971).

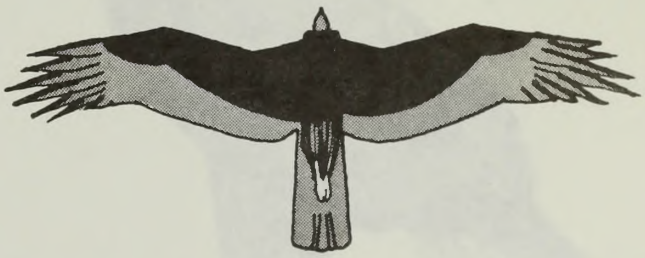
ADULT GOLDEN EAGLE

JUVENILE GOLDEN EAGLE

ADULT BALD EAGLE

JUVENILE BALD EAGLE

BLACK VULTURE



TURKEY VULTURE

Figure 1. Flight silhouettes of the golden eagle *(Aquila chrysaetos)*, the bald eagle *(Haliaeetus leucocephalus)*, the black vulture *(Coragyps atratus)*, and the turkey vulture *(Cathartes aura)*.

ADULT GOLDEN EAGLE

JUVENILE BALD EAGLE

JUVENILE GOLDEN EAGLE

Figure 2. Adult and juvenile golden eagle (*Aquila chrysaetos*) and a juvenile bald eagle (*Haliaeetus leucocephalus*).

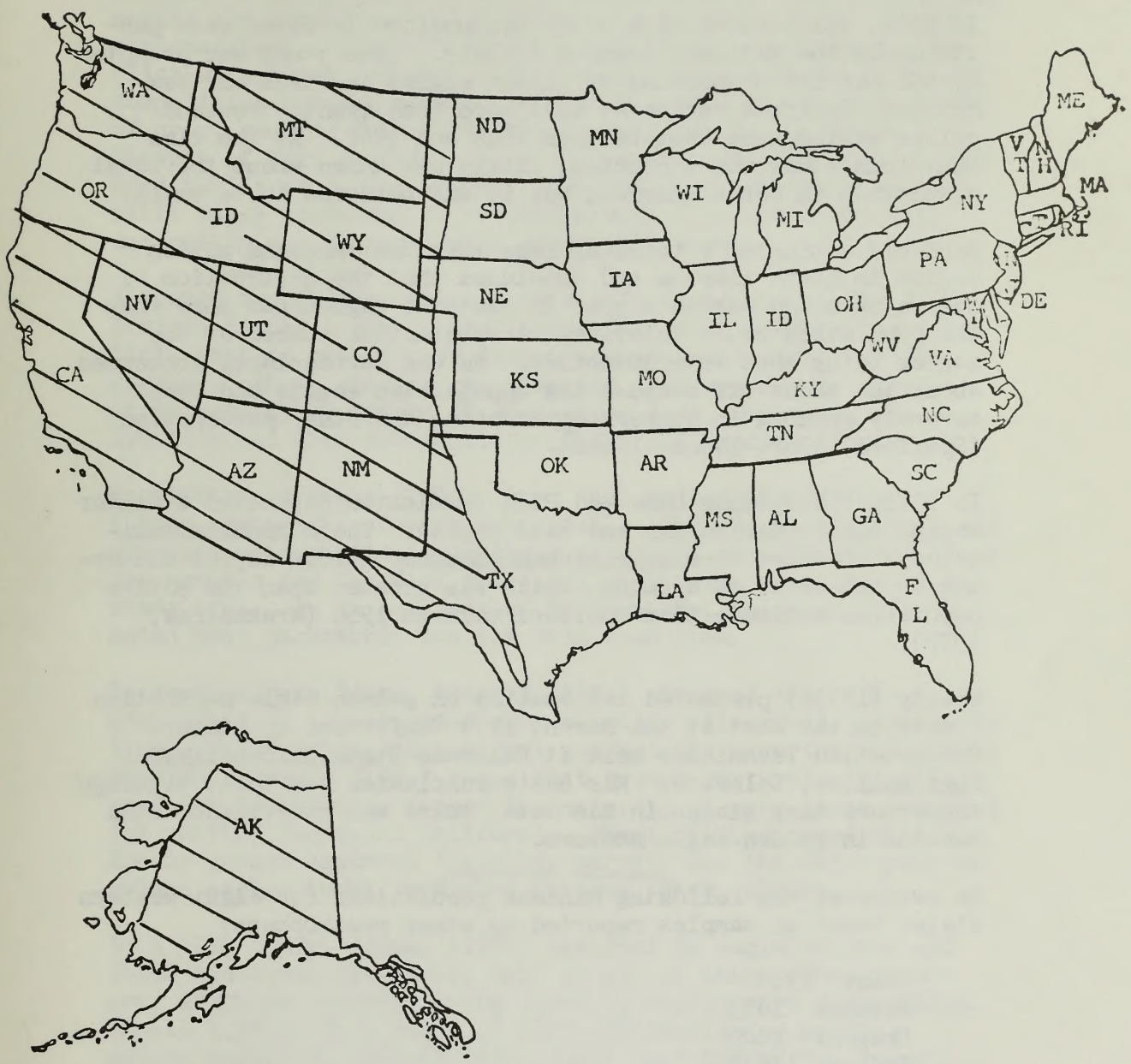


Fig. 3. Distribution of the golden eagle in the western United States and Alaska.

In the United States, the greatest concentrations of golden eagles are found in the western states, particularly in mountain habitat and intermontane valleys.

3. Status and Population Trend

In 1964, the results of a study by Spofford in Texas were published by the National Audubon Society. This study was prompted by the extensive shooting of golden eagles in Texas and New Mexico. Spofford estimated that more than twenty thousand golden eagles were shot between 1942 and 1962. At the time that this study was conducted, little was known about the total population in North America, but it was believed to be small.

Spofford estimated a total of less than ten thousand golden eagles in North America and concluded that the destruction of over a thousand eagles a year in just one region was more than the population could tolerate. A substantial number of the eagles being shot were juveniles. He was particularly concerned about the shoot-off because the Appalachian eagles had been severely reduced in numbers by shooting and other persecution (Spofford, 1962, 1964a, 1964b).

In 1972, the Wyoming Game and Fish Commission conducted a winter aerial survey for golden and bald eagles. Their results indicated that there were over eleven thousand golden eagles wintering in the state of Wyoming, which was greater than the entire population estimate that Spofford made in 1964 (Wrakestraw, 1972).

Heugly (1973a) presented information on golden eagle population trends in the West at the March, 1973 Conference on Raptor Conservation Techniques held at Colorado State University, Fort Collins, Colorado. His basic conclusion was that, although there were many biases in his data, there was no evidence of a decline in golden eagle numbers.

He estimated the following minimum populations for eight western states based on samples reported by other researchers:

Utah: 1367
Nevada: 1833
Oregon: 1600
Idaho: 1383
Montana: 2433
New Mexico: 2050
Colorado: 2600
Wyoming: 3063

Heugly feels that a conservative population estimate for golden eagles in North America is between fifty and one hundred thousand birds.

4. Life History

The flight of the golden eagle is powerful and graceful and it is an impressive hunter. Berkut golden eagles in Siberia are trained to kill wolves and other large quarry. American golden eagles are capable of killing deer and antelope under certain circumstances. Since it is a hunter, it is sometimes in conflict with human beings, as in some situations there is direct competition between people and golden eagles for certain kinds of prey, ranging from rabbits and pheasants to livestock. Because of this conflict there is considerable interest in the food habits of golden eagles. Many studies have been and are still being conducted to determine what a golden eagle eats seasonally and in particular geographic areas.

Although the golden eagle shows a wide diversity in its food habits, it has a strong preference for small mammals, particularly rabbits and rodents (which compete with livestock for forage). These species may comprise from seventy to ninety-eight percent by weight of an eagle's diet, depending on locality and prey availability (Brown and Amadon, 1968).

In Montana, McGahan (1966) found that whitetail jackrabbits (Lepus townsendi), desert cottontails (Sylvilagus auduboni) and mountain cottontails (Sylvilagus nuttalli) represented 80.1% of the mammals and 69.8% of the total prey taken by eagles in his study area. In an analysis of 51 stomachs, Woodgerd (1952) noted that jackrabbit was the main food item.

In southwestern Idaho, Kochert (1972) observed that 83% of the prey items he investigated were mammals. Blacktail jackrabbits (Lepus californicus) and desert cottontails were the major prey species. Carnie (1954) found that ground squirrels (Citellus sp.) and jackrabbits formed the majority of prey items recorded for nesting eagles in California. Murie (1944) noted that the Arctic ground squirrel (Citellus parryi) was the major prey of golden eagles in Mt. McKinley National Park, Alaska.

In a Utah study, Hinman (1960) analyzed 62 eagle pellets and found blacktail jackrabbit hair in all of them. Most of the prey which he observed being taken by eagles were jackrabbits. Arnell (1971), in a study of prey utilization by nesting golden eagles in central Utah, found that 96% of the items brought to the nests were mammals. Ninety-five percent of the mammals were lagomorphs, primarily blacktail jackrabbits, which comprised 78% of the total prey.

D'Ostilio (1954) found that cottontails comprised 58.5% of the total food items inspected in northern Colorado eagle nests. Jackrabbits were 11.3% and prairie dogs (Cynomys sp.) were 8.2%

of the total. Olendorff (1973) found that over 87% of the prey taken by golden eagles on the Pawnee National Grasslands, northeastern Colorado, were cottontails and jackrabbits.

The predation of golden eagles upon big game species has many times in the past resulted in eagle control in the belief that predation by these large raptors was injurious to the game populations. Studies indicate that while predation on large ungulates does occur, the impact of golden eagles on these populations is negligible.

D'Ostilio (1954) found that three percent of the food items recorded from five Colorado nests consisted of mule deer (Odocoileus hemionus) remains. Murie (1944) observed the remains of dall sheep (Ovis dalli) in 2.4% of 632 eagle pellets which he analyzed in Mt. McKinley National Park. Woodgerd (1952) found antelope (Antilocapra americana) hair in 8 of 51 Montana eagle stomachs. McGahan (1967) noted that 3.4% of the prey items he checked consisted of mule deer. Arnell (1971) found no evidence of predation on deer or other big game in his examination of 518 food items and 41 pellets from golden eagle nests in central Utah.

Hinman (1960) studied eagle-antelope relationships in southwestern Utah. Population estimates were 125-150 antelope and 25-30 eagles. No attacks were observed on antelope. Does with fawns usually paid little attention to eagles that were in the vicinity. Only one eagle-killed fawn was found. Eagles were never observed harassing antelope, although they were sighted over them.

Golden eagle attacks on adult antelope have usually occurred during severe winter weather, during periods of food scarcity, or both. Although golden eagle predation may have an influence on a local population in a very restricted area, it is unlikely that this is of particular significance.

Wyoming has one of the largest populations of golden eagles in the western states, yet a remnant population of antelope which numbered less than 5000 in 1900 increased to a point where over 41,000 were harvested in 1952. Little predation was noted on antelope during a study in 1947 in northern Colorado on the Colorado State Antelope Refuge. The population of antelope in this area increased from 250 in 1939 to more than 500 in 1947, when the eagle population was near maximum. It would seem that the eagles present had no appreciable influence on that antelope population (Kalmbach et al, 1964).

Studies in the Tarryall Mountains and Rocky Mountain National Park, Colorado; Crystal Creek, Wyoming; Sun River, Montana;

New Mexico and Idaho indicated very little or no predation on bighorn sheep (Ovis canadensis) in these areas. Some predation on bighorn lambs was noted in a study in Nevada, but the relative significance of this predation was not indicated. Available evidence also suggests that golden eagles have only a minor influence on deer populations (Kalmbach et al, 1964).

Sight records of eagle predation are rare, but there are a few in the literature. Attacks have been observed on coyotes (Ford and Alcorn, 1964), antelope (Lehti, 1947; Bruns, 1970), whitetailed deer (Willard, 1916), mallard ducks (Kelleher and O'Malia, 1971) and bighorn sheep (Kalmbach et al, 1964).

Remains of big game found at eagle nests are often the bones of fawns which were stillborn, died shortly after birth or were killed by eagles (Carnie, 1954; McGahan, 1967; Brown and Watson, 1964; D'Ostilio, 1954). Many of the birds which golden eagles capture are often recently fledged (Beecham, 1970). Pheasants and sage grouse appear to be particularly vulnerable during breeding season. However, sage grouse do most of their strutting before eagles are hunting in the early morning, and it is probable that relatively few grouse are taken during this time (Kalmbach et al, 1964). Kochert (1972) discovered that most pheasants in his study area were taken during the peak of pheasant breeding activity.

Golden eagles are carrion eaters. For many years it was supposed that the golden eagle would eat only what it had killed. An experiment conducted by C. C. Sperry in the vicinity of Fort Davis, Texas, showed that the carcass of a jackrabbit or a lamb that had been dead for two or more days was preferred even though live lambs of all ages were in the immediate area.

It has been a common procedure among stockmen in the Southwest to trap or poison golden eagles with fresh carcasses. Some ranchers have remarked that when it is available, golden eagles will consume fresh carrion instead of killing prey. In areas where many rabbits are killed on highways, a number of golden eagles are also destroyed when they are hit by automobiles as they feed on the dead rabbits. Golden eagles have also died when they ate rodents killed by poison grain used in rodent control (Kalmbach et al, 1964).

In a study in Scotland, Brown and Watson (1964) discovered that sheep and deer carrion formed 25% of the eagle diet by weight in the summer and approximately 38% in the winter. In some instances, the circumstances were such that as much as 60% of the winter diet might consist of carrion.

Perhaps the most controversial aspect of golden eagle predation concerns the killing of livestock, particularly sheep and goats. This predation and its supposed devastational effects on herds in Texas is given as the reason behind the annual shootoff of eagles from the 1940's to the 1960's. Most of this killing was done from airplanes (Spofford, 1964).

The greatest pressures for eagle control come from sheep and goat ranchers. In many instances, cattlemen are at least neutral in their attitude toward eagles, and many feel that any damage golden eagles might do to their cattle is negligible compared to the benefits derived by the removal of the rabbits and rodents which compete with their livestock for forage (Kalmbach et al, 1964).

The domestic sheep is a man-controlled, highly bred exotic species and as such has no natural defenses against the hostile elements in its environment in this country. Despite this fact, there is an increasing tendency to replace sheep herding with large, fenced pastures where the sheep are left unguarded.

When factors such as range utilization, relative abundance of mammalian predators, presence or absence of other prey species, time of lambing, availability of carrion, unexpected freezing weather, unseasonal and severe storms, extremely hot weather, screw worms, diseases and the effects of poisonous plants are considered, any attempt to determine the impact of eagles on livestock losses is very complicated. Sheep management methods have a definite influence on sheep mortality.

Kalmbach et al (1964) reported on two study areas, one north of Fort Collins, Colorado and the other in west Texas. The Colorado-Wyoming region was an area of foothills, scattered buttes and open prairie, with brushy cover on the slopes. The estimated golden eagle population was approximately one pair per township. Sheep in the area were usually herded in flocks of about 600. Lambing occurred from the end of March through mid-May, usually in lambing sheds with the ewes and their lambs being confined for ten days. The flocks were kept under close supervision and grazing pressure was moderate to heavy. The sheepmen in this area felt that the eagle was no problem, and none of them had ever seen eagle predation on sheep. They did observe that eagles quickly found dead sheep and ate them.

The Texas area west of the Pecos was characterized by scattered mountain ranges which were separated by rolling hills and flat valleys and scrub in the lowlands, or semiarid grassland with scattered brushy cover on the steeper slopes. The sheep were restricted to fenced areas. The peak of lambing occurred around the middle of March and took place in the pastures

instead of in sheds. Grazing was heavy to extremely heavy, and land use would be considered by some to be abusive. Although it was rare to see an eagle actually kill a lamb, examination of carcasses indicated that some of them had been killed by claw punctures at the base of the skull. Ranchers agreed that eagles seldom bothered lambs more than seven to ten days of age.

Available information suggests that losses of lambs and kid goats are spasmodic and vary according to prevailing circumstances. Spofford (1964) noted that the vegetation in many areas of the Edwards and Trans-Pecos Plateau in Texas was very poor, so poor that the sheepmen stated they were selectively breeding their sheep to graze apart from each other so that they could get enough to eat. This practice probably increased the opportunities for avian and mammalian predation on the sheep. Spofford also observed a number of lambs separated from their mothers, which made them prime candidates for predation as well as mortality from other causes, such as starvation.

Mollhagen et al (1972) noted the bones of several lamb carcasses in two particular eagle eyries, suggesting that specific individuals may be preying on livestock. McGahan's study was located in an area where 26,000 to 28,000 sheep were raised annually, yet there was no instance of any domestic animal being taken by eagles in the survey he made of golden eagle food habits (McGahan, 1966).

Spofford also made the observation that sheep ranchers continued to report heavy losses despite the decimation of eagles in certain areas. He reported a general agreement among them that there was no problem with eagles in the area until the land was cleared of juniper and oak as supposed range improvement carried out under federal subsidies. One of the effects of this so-called improvement was the increased exposure of lambs and kids to predation and other factors such as harsh weather.

Brown and Watson (1964) also noted that sheep mortality in Scotland varied with sheep management methods used. Where the ewes were hand fed in the spring and carefully looked after, lambing success was 100 to 150 lambs per 100 ewes. The number of dead sheep and lambs was very low. Where this care was not taken, lambing success might be 80 lambs per 100 ewes and the losses of full-grown sheep were around 9%.

Brown and Watson found that a very low proportion of total lamb loss was due to the killing of live lambs by golden eagles. On one area, it was estimated that one pair of eagles probably

killed only seven lambs in five years. There were at least 4000 lambs on the area during this time, and a minimum of 520 died from other causes. Losses to eagles were infinitesimal compared with the heavy losses resulting from low-quality management.

Lockie and Stephen (1959) conducted an investigation of eagle-sheep relationships on the Isle of Lewis, Scotland. The island was heavily overgrazed and mortality of sheep and lambs was naturally high. Many of the lamb losses were a result of inadequate milk from the ewes. The ewes also suffered from deficiency diseases, losing their teeth and their horns. By 1944, there were about 65 lambs per 100 ewes surviving.

Food remains examined at two eyries in an eagle depredation complaint area consisted of rabbits, grouse, golden plover, hares and rats. No lamb remains were found. Although the bones of two lambs were found at a third eyrie, the keeper of the sheep had investigated and determined that these lambs were carrion when the eagles picked them up.

The eagle population began to increase around the same time that mountain hares and grouse began to decrease. Simultaneously, the number of sheep being maintained increased. Since sheep and lamb mortality was quite high, it seems likely that the amount of carrion present more than adequately compensated for the decrease in the number of hares and grouse available. Lockie and Stephen noted a parallel in the Pecos district of west Texas, where the herding of goats and sheep was inadequate, grazing pressure extremely heavy, land use rather abusive and wild prey somewhat scarce.

One of the major items of contention between stockmen and environmentalists concerns the determination of whether the stock animal was an eagle kill or if it died of other causes and the eagle was utilizing it as carrion. It is apparent that there is some loss of livestock through eagle predation, but many factors are involved in this.

Heugly (1973b) reported on observations he made on golden eagles and lambs and kid goats in two pastures. Of all the lambs that died, one fourth to one third were eagle kills, although these kills were not witnessed. One fourth of the kid goat mortality was a result of eagle predation. Nanny goats frequently left their kids alone, thus increasing the likelihood of a given kid to succumb to mortality from a number of causes. Heugly also noted that most of the eagle-killed lambs had been abandoned. These were open pasture situations without human supervision. Approximately two thirds of the eagles taking lambs and kids were juveniles.

Wiley and Bolen (1971) reported on the wound characteristics made by golden eagles and the various situations surrounding possible eagle predation when an eagle is flushed from a carcass. Close examination of the details is important because of the utilization of carrion by eagles and the frequency with which eagles are seen on livestock carcasses, particularly in certain areas and at certain times of the year.

Wiley and Bolen described a number of situations in which eagle predation might be involved in livestock mortality: (1) "pure" predation, where a healthy animal was taken by an eagle; (2) carrion feeding, where the lamb or kid was dead from other causes; (3) enhanced predation, where the lamb or kid was suffering from disease, congenital faults or other factors; (4) predation by an eagle, with the carcass being used by other species and then by an eagle again.

The first three situations are the ones most often encountered. The third one is the most difficult to detect, and may at times and in some places be very important. Big game studies have generally shown that the unfit members are the most vulnerable to predation and all other things being equal will be the first to be taken by predators. Culling effects among livestock are very difficult to determine because of the fact that sheep in particular are an exotic species and not adapted to their environment.

Talon punctures and extensive subcutaneous hemorrhaging are usually present on the dorsal surface of eagle-killed prey (Wiley and Bolen, 1971; Alford and Bolen, 1972; Brown and Watson, 1964). The absence of hemorrhaging beneath the skin around a puncture wound indicates that the animal was dead when that particular wound was inflicted. Wiley and Bolen also checked the hooves of lambs. Lack of soil or debris in the hoof cleft or no evidence of hoof wear suggested that the lamb or kid was stillborn and any subsequent damage to the body was the result of scavenging.

Wiley and Bolen placed jackrabbit carcasses in an open field and observed the feeding patterns of eagles as well as other carnivores. They examined the carcasses afterwards and established some criteria for the types of scavengers feeding on the carcasses.

Removal of the eyes and tongue was usually done by a raven or a vulture. If the bones were picked and unbroken, with the tissues cleanly removed from the larger bones, avian damage was indicated. They observed a bald eagle clip the ribs flush with the vertebrae, but the meat was cleanly picked from the

legs and shoulder bones. Roughly broken or chewed bones were indicative of mammalian damage, and tooth marks were frequently visible. If the skin was cut or partly removed from the body, an avian predator had been at the carcass.

The lack of talon punctures on a lamb's body is not accepted by some stockmen as proof that an eagle did not kill a lamb. According to them, the lambs are killed by the impact of an eagle striking with its feet closed into a "fist" or in some other way that does not involve the use of the talons (Alford and Bolen, 1972).

A survey of the instances of observed eagle predation which have been reported in the literature substantiates the fact that eagles do use their talons when killing prey. Sperry (1957) and Alford and Bolen (1972) observed eagles attacking decoy ducks, making deep talon punctures in the bodies of the decoys. A whitetailed deer found dead in deep snow and supposedly killed by eagles also had deep talon wounds (Willard, 1916). Lehti (1947) reported that an eagle-killed doe antelope had many talon punctures on her back and the nape on her neck.

Nelson (1962) also reported that eagles kill their quarry by the crushing grip and penetration of their talons. Although eagles are capable of killing large animals, these occasions are rare when compared to the number of small quarry taken.

A golden eagle requires certain circumstances to make a kill. The size and hunting skill of the eagle and basic principles of aerodynamics are involved in success or lack of success. Eagles need thermal updrafts or escarpment updrafts to gain altitude for hunting or moving across country. An eagle in an established territory learns the terrain and seeks updrafts which will carry it through a downdraft or dead air to the next updraft.

Wild eagles seldom kill in the center of a downdraft area because they apparently know that they can't fly with even one pound of food and get into the next updraft. Eagles have been found in the center of a downdraft region or a dead air space with their crops full and unable to get into the air. Camenzind hand-caught a juvenile with an engorged crop in the middle of Cedar Valley, Utah, a downdraft area, in November, 1968 (Murphy, 1973b).

When it has become an experienced hunter, an eagle uses a favorite perch near the area from which it can get into the closest updraft. Then it rises to an elevation which will bring it to its hunting grounds. This altitude of flight permits it the command of a wide circular area usually somewhat upwind of the eagle.

In most instances, an eagle attacks into the wind for the aerial control necessary to capture a quarry which is dodging around on the ground and being forced to run into the wind. The eagle drops rapidly and at the last instance spreads its wings and tail and extends its legs, using its feet to bind to the quarry. When a successful kill is witnessed, it appears to be a very simple act for the eagle to accomplish. However, because certain conditions are necessary for success, and because there are a number of variables involved, it is not at all unusual for an eagle to miss its prey up to 90% of the time (Nelson, 1962).

Recently fledged juvenile eagles are very uncoordinated and prone to making many mistakes. They have difficulty landing properly or maneuvering in the wind. When they first start hunting, they may chase their quarry in a direct line, which is an unsuccessful approach. Flying with the wind after quarry also disrupts their control and results in misses (Nelson, 1973).

The weight that a golden eagle can carry in the air for any length of time is limited. This is particularly important when there are eaglets in the nest which must be fed. Considerable amounts of energy must be expended to pursue and capture prey, so it is likely that eagles tend to expend the smallest amounts of energy necessary for the largest return. Part of that expenditure involves flying to the eyrie with food for a mate or the young. Brown and Watson (1964) calculated that the average weight of a kill which is usually carried by an eagle to its eyrie is approximately two pounds.

Nelson (1962) tied a total of eight pounds of weights to the feet of a trained eagle and it could not get off the ground, even under excellent wind conditions. Walker and Walker (1940) also used a trained eagle for similar tests. They launched their bird from a fifteen-foot-high platform with a wind of 10 mph blowing. Carrying two pounds, the eagle flew easily. With a weight of four pounds attached, flight was strained and the distance it was able to fly was much shorter than when carrying two pounds. When eight pounds were attached to this eagle, it flapped its wings wildly and landed immediately after being launched from the platform.

In 1937, C. C. Sperry conducted tests on the weight-lifting ability of a wild eagle and discovered that an eleven-pound eagle could not get off the ground with 5¼ pounds of weights attached to its feet. Another observer saw an eagle carrying a seven-pound jackrabbit, but the weight of this eagle is not known. When carrying a burden the size of a ground squirrel, an eagle will often fly a circuitous route to its eyrie, utilizing the lifting power of available air currents and thermals (Kalmbach et al, 1964).

The size of the object carried in flight will vary with the characteristics of the individual eagle, its incentive, the altitude at which it is flying, wind conditions, immediate flight speed and other factors such as time of day, terrain and prior experience. Once the momentum of the initial thrust is lost, the eagle is dependent on its own heavy flight or irregular air movements (Kalmbach et al, 1964; Nelson, 1962).

Huey (1962) compared the weight-lifting capacities of a house finch and a golden eagle. He noted that a finch weighing 20.85 grams carried a load of 4.88 grams, which was 23% of its body weight. A golden eagle which weighed 4169.4 grams carried a load weighing 907 grams, which was 21% of its body weight.

Wild eagles apparently do not eat every day. After a large meal they can go without food for several days and remain in a healthy condition (Brown and Watson, 1964). This is one more factor which complicates any attempt to determine the food requirements of eagles and the possible impact of eagle predation on a prey population.

Fevold and Craighead (1958) conducted studies on the food consumption of captive eagles at the Montana Cooperative Wildlife Unit. They maintained one female and two male eagles in outdoor pens. The percentage of body weight consumed by the female was 5.7%. The males consumed 6.6% and 6.5% of their body weights. Large species of raptors consume less food in relation to their body weight than smaller raptors and it may be that the female of the species has a metabolic rate that differs from that of the male. This may account for the differences noted in food consumption of these eagles, but more studies are needed. Mosher (1973) discovered no differences in metabolic rates of male and female broadwinged hawks (Buteo platypterus).

Fevold and Craighead noted that the percentage of body weight consumed decreased with an increase in the daily temperature. An eagle which was exercised in warm weather ate more than an eagle which was not exercised. In the fall and winter, the two males consumed an average of 262-266 grams of food a day; the female consumed an average of 308 grams per day. Brown and Watson (1964) noted that eagles in captivity would consume an average of 3/4 pound per day, but that when they were moulting, they ate more than one pound of meat a day.

McGahan (1967) made quantified estimates of predation by a golden eagle population. (See Jour. of Wildl. Mgmt. 31(3):496-501 for complete details.) Estimates of consumption and predation were obtained by combining values quantifying the feeding behavior of eagles with data from a list of prey items which were taken by the collective eagle population. An average

weight value for each species of prey was determined and data were put into a formula which produced an average figure of 490 grams of food consumed per eagle each day. Based on the observed food brought to eagle eyries during this time, 40 to 49 prey individuals were taken per unit eagle over the 100-day time span.

If one substitutes an average value of 286 grams, the minimum daily food requirement of captive golden eagles, a minimum of 23 to 28 prey items would be taken per wild eagle per 100 days. Wastage of edible portions is not considered in these calculations. This estimate is conservative since wild eagles probably need more food than captive eagles. The energy requirements of free existence have been estimated to be around 30% to 50% greater than caged existence for raptors (Gessaman, 1973).

McGahan obtained an estimate of predation by the total eagle population by multiplying the values for a unit eagle by the number of eagles in the entire population. In 1963 a population of 60 eagles took an average of 19 to 23 prey items per ten square miles during a 100-day period. In 1964, the total population was approximately 70, for an average of 22 to 27 prey items taken per ten square miles per 100 days.

Brown and Watson (1964) assumed that a wild golden eagle would eat 230 grams of meat a day, producing a total annual requirement of 84 kilograms per eagle. They estimated that the home range of a pair of eagles must provide 168 kilograms of meat annually for the adult pair, 39 kilograms for rearing one eaglet, and 42 kilograms for that eaglet when it had fledged, a total of 249 kilograms. Allowing for wastage, at least 321 kilograms of meat would be required to support these three eagles in one year.

Brown and Watson learned that the potential weight of prey in the areas studied varied from nine to 58 times the estimated requirement of 321 kilograms. The potential available edible carrion alone varied from eight to 74 times the minimum requirement of meat required to support three eagles.

Olendorff (1973) compared the adult raptor biomass with the rodent and nonraptor avian biomass present in his study area of the Pawnee National Grasslands. Rodent biomass was more than 200 times the raptor biomass present, and nonraptor biomass averaged between 62 and 95 times the raptor biomass in the area.

During 152 days in 1972, adults and young combined removed about 6% of the nonraptor avian and rodent biomasses. Similar calculations for the previous year showed that raptors took only 3.8% of the available biomass. Cottontails, jackrabbits and pocket gophers were not included in the prey biomass available because population densities were not known for these species. Addition of these species would increase the prey biomass considerably.

Golden eagles occupy definite territories, which include feeding, roosting, nesting and soaring-playing areas. The size of the territory depends to a certain extent on availability of food, nest sites and suitable terrain for flying (Kalmbach et al, 1964).

In a 540-square-mile study area in Utah, Camenzind (1968, 1969) found one pair of eagles per 38 square miles in 1968. Dixon mapped the territories of 27 pairs of golden eagles in California and found they ranged from 19 square miles per pair to 59 square miles, with an average of 36 square miles (Dixon, 1937).

In Montana, McGahan (1966, 1968) located 19 pairs in 1964 for an average density of one pair per 66.3 square miles. Reynolds (1969) studied the same area and located 23 pairs in 1967 for an average of one pair per 54.8 square miles.

Reynolds studied one eagle territory closely and discovered that the pair spent most of their time in a thirteen-square-mile area, but used a total area of 32 square miles. Dixon (1937) found a direct relationship between the amount of actual hunting ground available and the overall size of the occupied territory. The actual geographical area occupied by eagles living in hilly terrain was smaller than a territory set up in open, flat country.

Kochert (1972) found that the density of known breeding pairs of golden eagles in southwestern Idaho varied from one pair per 35.5 square miles in 1970 to one pair per 25.4 square miles in 1971. This approaches the densities observed in Scotland by Brown and Watson (1964) where the territories of golden eagle pairs ranged from 17.8 to 27.9 square miles.

Olendorff (1973) observed a breeding density of golden eagles on a 414-square-mile study area in the Pawnee National Grasslands of somewhat over 200 square miles per pair in 1971 and between 125-150 square miles in 1972. However, the grasslands are probably marginal habitat for golden eagles since not much suitable nesting habitat is available. Kalmbach et al (1964) reported a density of one pair per 36 square miles in a study area north of Fort Collins, Colorado.

Apparently golden eagles become quite attached to their territories, as they will return to the same nesting area year after year, even if young are not produced and/or successfully fledged (Kalmbach et al, 1964; Kochert, 1972). If both members of a pair are killed, their territory will be occupied by another pair of eagles, sometimes in the same season (Kalmbach et al, 1964).

The time of courtship for golden eagles varies with the altitude and latitude. Murie (1944) reported golden eagles arriving in Mt. McKinley National Park in March, with the eggs generally hatching in June. Campbell (1960) estimated that eagles nested in the Brooks Range near Anaktuvak Pass at the end of April or very early May. In the more southerly regions of its range, where the golden eagle may remain in the vicinity of its nesting territory for the entire year, courtship begins much earlier.

Bent (1937) lists five records for egg laying dates in Arctic America, ranging from May 27 to June 29. He lists 272 egg laying records for eagles from California to Texas. The dates for these records range from February 9 to May 18. For 136 of these records, the dates are February 26 to March 24.

Golden eagle courtship is similar to that of many Buteo hawks, and consists mainly of rather spectacular flight maneuvers. The most typical nuptial display is an undulating series of dives followed by climbing swoops, with a few flaps of the wings at the top of each swoop, then falling 50 to 100 feet and climbing again. This is usually performed by one bird at a time. The pair may also fly in spiraling climbs in which they frequently come close together and then drift apart, almost touching each other as they pass. The male may dive towards the female, who turns on her back and presents her claws (Brown and Amadon, 1968; Bent, 1937). Courtship behavior may be continued throughout the nesting season (Kalmbach et al, 1964). Kochert has watched undulating displays even after the young have fledged (Kochert, 1973c). Golden eagles are usually assumed to form pairs which last until one mate is killed or dies. More studies are needed to verify this fact.

Golden eagles usually have a number of alternate nests, ranging from one to 14, although two to three alternate sites is the usual number (Kochert, 1973c; Murie, 1944; Camenzind, 1968, 1969; Hinman, 1960; Bent, 1937; D'Ostilio, 1954; Carnie, 1954; McGahan, 1966, 1968). The same nest may be used by a pair during consecutive nesting seasons, although they often repair alternate nests and visit them regularly until the eggs are laid (McGahan, 1968; Murie, 1944).

Nest defense is variable. Kochert (1972) observed that immature eagles can move in and out of nesting areas without producing defensive reactions from the adults, but another adult will not be tolerated in the area. Golden eagles seem to be neutral towards other species of raptors entering their territory, but Kochert (1972) noted that in the Snake River Birds of Prey Natural Area, where prairie falcons also nest in high numbers, there are many antagonistic encounters between prairie falcons and eagles. Such action is initiated by the falcons, which have never succeeded in driving a golden eagle from its own nesting territory.

Nest defense against human beings seems to be almost universally lacking. The adult eagles are extremely wary when a person comes near the eyrie, and in many cases will be gone before the observer is even aware of the nest. This wariness is probably an important factor in adult survival, decreasing the opportunity for human-inflicted mortality.

Camenzind (1968) noted that only three pairs of eagles in his study area exhibited defensive behavior of any kind. One female could be approached and almost touched before she would leave her nest. Another eagle would circle the observer at close range. The third female could be touched before she would fly, and then she would not go very far from the nest area.

The usual clutch of eggs is two, although sets of one and three are also laid. The female does most of the incubating (Camenzind, 1968; Bent, 1937) although the male performs a small portion of this task (Brown and Amadon, 1968; Jollie, 1943). The male also shares in brooding the young eaglets (Jollie, 1943; Kalmbach et al, 1964; Brown and Amadon, 1968).

Golden eagles may readily abandon their eyries at certain times of the breeding cycle with little apparent interference from human beings. Incubation has been determined as the most critical period during which eagles will desert the nest. Once the young have hatched, the chances of desertion decrease (Kochert, 1972; Hinman, 1960; Kalmbach et al, 1964).

The period of incubation has been variously given as 35 days (Kalmbach et al, 1964; Bent, 1937; Brown and Amadon, 1968; Carnie, 1954), 41 days (Reynolds, 1969; Camenzind, 1968; Olendorff, 1973) and 43 days or more (Camenzind, 1968; Hobbie and Cade, 1962). Studies are needed for a more exact determination.

During the first two to three weeks after hatching, at least one parent is present at the nest, and the female is very attentive to the eaglets. The male does most of the hunting during this time (Jollie, 1943; Reynolds, 1969). Although the nest is kept clean of food remains during incubation, this is not the case once the eaglets have hatched. After they reach three weeks of age, when their feathers start appearing, the eaglets are no longer brooded (Camenzind, 1968; Brown and Amadon, 1968). The female usually feeds the eaglets prey which she or the male has brought to the eyrie. Camenzind (1968) also noted that the female will frequently shade the young birds with outspread wings where the nest is completely exposed to the sun.

There may be a two-to-four-day interval involved when the eggs are laid. Since incubation begins with the laying of the first egg, one eaglet is usually larger than the other. Brown and Amadon (1968) stated that in 80% of the instances where two young are hatched, the older will kill the younger. However, in his studies in Idaho, Kochert (1972) observed only one certain incidence of fratricide in the deaths of 25 nestlings. Fratricidal conflicts were not observed between eaglets after the age of three weeks, but Kochert feels this may account for some eaglets which disappeared from the nest. Arnell (1971) found that 6 of 14 nesting pairs under observation in 1969 in Utah produced 3-egg clutches. Of these six, five pairs fledged all three young.

Sumner (1929) made some observations on the growth and behavior of young golden eagles. He noted that a newly hatched chick was unable to distinguish objects and chirped incessantly. As the eaglets grew older, they showed increasing resistance to being handled. The smaller eaglet was more aggressive, striking Sumner's feet, hissing and keeping its wings raised. Kochert (pers. comm.) and Arnell (1971) have also observed that many times the smaller eaglet is more aggressive.

The age of fledging is usually given as nine to ten weeks (Kalmbach et al, 1964; Sumner, 1929; Brown and Amadon, 1968; Hobbie and Cade, 1962; Bent, 1937). However, fledged eaglets seem to be dependent on their parents for some time afterwards, until they are 100 days old or older. The parents often watch and guard them and the juveniles may remain in the vicinity of the nesting territory for some time after this (Hobbie and Cade, 1962; Kalmbach et al, 1964).

Post fledging movements have been poorly documented. Kochert (1972) noted that dispersion appears to be random in all directions. Most of the eagles from his study area seem to be attracted to areas of southwestern Idaho. Fifty-two of 56 banded eagles four months to four years old were found dead

within 108 miles of the eyries where they hatched (Kochert, 1973c). Adult eagles remain near their nesting territories throughout the year. It appears that it is primarily the eagles from the more northern extent of their range that move southward and in any numbers (Bent, 1937; Brown and Amadon, 1968).

McGahan (1966) also noted a local or intra-range movement during the annual cycle. Information which Boeker and Ray (1971) collected indicated that golden eagles nesting along the Front Range in Colorado and Wyoming are also resident. This is supported by the observation that when eagles in these states are nesting, there are still large numbers of eagles in New Mexico which are probably Arctic migrants.

Although bald eagles have been found in large concentrations at winter roost sites, golden eagles have not been found gathered together in a similar fashion. Mated pairs remain associated with their territories or roost singly. Juvenile golden eagles use a variety of roosts, including power poles, well derricks and rock outcroppings. It is not unusual for juvenile golden eagles to roost with bald eagles (Edwards, 1969).

The amicability between golden eagles and bald eagles extends to juvenile golden eagles roosting with bald eagles in the same tree and sometimes even on the same branch. Golden eagles and bald eagles have been observed sharing kills in Utah (Edwards, 1969). Murphy (1973b) has a number of recorded observations from Park Rangers in Yellowstone National Park reporting winter sightings of bald and golden eagles feeding together on carcasses of winter-killed game.

The basic response towards human beings tends to be one of extreme wariness on the part of the adults. Juveniles seem to require some experience with mankind before they become equally wary. Inexperienced fledglings in the process of learning to hunt have possibly on two occasions mistaken a human being for a new kind of prey item. Gullion (1957) reported two incidents in which juvenile golden eagles descended from quite a height down at him as he was emerging from heavy forest onto exposed ridges in Washington. He felt that since this was an area which was not frequented by people, from the altitude at which the eagles were flying a man would have no more apparent size than a marmot. When the eagles got close to him and he yelled, they no longer stooped at him.

The golden eagle is primarily silent. Phonetic descriptions have been given to various calls which golden eagles make when an occasion warrants it. Brown and Amadon (1968) described a loud, clear yelping call as 'weeeo-hyo-hyo-hyo.' They also mentioned mewing cries, 'weee-o', given in displays. The other

sound they described for adults was a thin, shrill 'pleek' or 'tsewk.' Young eaglets which were soliciting brooding or food made clucking calls sounding like 'tsyuck-tsyuck.' When angry, eagles emit a harsh, high-pitched chattering.

Bent (1937) described the usual call note as a shrill 'kee-kee-kee' delivered in high tones. The alarm call was described as 'kiah-kiah' repeated a number of times. He also described a scream as being 'cheop cheop, tsyewk tsyewk' given slowly. Kochert (pers. comm.) has noted that during courtship, the adult pair does a lot of what he calls 'happy-talking' or yarping.

Unlike certain populations of the southern bald eagle, which are suffering drastic declines in productivity, the golden eagle population as a whole appears to be reproductively healthy. In 1967-1968, Camenzind (1968, 1969) noted that the average number of eggs produced in a study area in central Utah was 1.91 per nest. In 1964-1965, McGahan (1966, 1968) noted an average production of 2.10 eggs per nest in Montana. Olendorff (1973) observed an average clutch size of 1.61 in 1971-1972 on the Pawnee National Grasslands in Colorado. Beecham (1970) and Kochert (1972) observed an average of 2 eggs per nest in Idaho during 1969-1971.

However, hatching success may differ considerably. Observed hatching success rates are 1.13 young per nest in Utah (Camenzind, 1968, 1969), 1.8 young per nest in Montana (McGahan, 1966, 1968), 1.06 young per nest in Colorado (Olendorff, 1973) and 1.62 to 2.1 young per nest in Idaho (Beecham, 1970; Kochert, 1972).

Fledging success is frequently lower than hatching success. This rate has been 1.56 eaglets per successful nesting attempt in Montana (McGahan, 1966, 1968), 1.73 eaglets in Utah (Murphy, 1973a) and 1.4 to 1.8 in Idaho (Beecham, 1970; Kochert, 1972).

When unsuccessful nesting attempts are also included in determining the overall productivity of the entire population, this figure is even lower. Overall productivity was .84 fledglings per pair in Utah (Camenzind, 1968, 1969), 1.32 fledglings per pair in Montana (McGahan, 1966, 1968), .97 eaglets per pair in Colorado (Olendorff, 1973) and .9 to 1.3 in Idaho (Beecham, 1970).

These figures tend to be slightly higher than those quoted by Brown and Watson (1964) for the productivity of eagles in Scotland, a rate of .8 fledglings per pair.

Productivity is lowered by the presence in the population of non-breeding pairs of adults. Brown (pers. comm.) feels that 10 to 30% of the total pairs in a given population may be non-breeding. A number of factors seem to be involved in this phenomenon, including the behavior of individual eagles. Kochert (pers. comm.) indicated that certain pairs of eagles in the Idaho study area have nested each year for the past eight years while other pairs are inconsistent breeders. This propensity may be related to availability of prey species. Some pairs apparently nest during alternate years (Boeker and Ray, 1971; Murphy, 1973a).

Human disturbance appears to be a major factor in nesting failure. Boeker and Ray (1971) noted that human disturbance was responsible for 85% of the nesting failures observed in their study of eagles along the Front Range of the Rocky Mountains in New Mexico, Colorado and Wyoming. Six of 13 nesting failures in Camenzind's Utah study (1968, 1969) were due to human interference. Where human pressures are great, eagles have completely abandoned their nesting territories and in some cases have moved to higher altitudes to nest (Murphy, 1973a). Twenty-one percent of the nesting failures in southwestern Idaho were man caused in 1970-1971 (Kochert, 1972).

Human disturbance may be direct or indirect: shooting of adults and/or young, collecting or destroying eggs, harassing the adults and keeping them off the nest for critical periods of time (especially during incubation and when the eaglets require brooding from the adults), implementing rodent and predator control programs involving the use of poisons, climbing cliffs which support eyries, camping below an active eyrie, and habitat destruction, such as housing developments and the establishment of large blocks of monotypic communities which result in the removal of golden eagle prey species (Kochert, 1972, pers. comm.; Boeker and Ray, 1971; McGahan, 1968; Reynolds, 1969).

Other causes of nesting failure include inclement weather, wind destruction of nests, nests sliding from cliffs because the accumulation of weight is too heavy, construction of nests in marginal gully sites and the subsequent washing out of the nests after a heavy rainstorm, eaglets falling from the nest, death of the eaglets from heat prostration or disease, and infertility of eggs (Kochert, 1972; Boeker and Ray, 1971; Olendorff, 1973; Snow, personal observation). In his Idaho study, Kochert (1972) noted that 22% of all the eggs laid in 1970 were infertile.

Brown and Watson (1964) feel that 75% of fledged golden eagles die before they reach sexual maturity. If the population is reproducing at a rate of less than one eaglet per pair per year, it would take one pair of eagles ten years to produce two birds to replace themselves.

Other studies corroborate a high mortality rate for juvenile golden eagles. From 1962 to 1968, 52 golden eagles were found dead in a study in Montana. Seventy-six point five percent of these were nestlings, 7.8% were juveniles and 5.9% were adults (Reynolds, 1969). Kochert (personal comm.) has conducted 63 autopsies on golden eagles in Idaho. Nineteen of these birds were adults, 44 were juveniles. A survey of a powerline in Cedar Valley, Utah, on a twelve-mile stretch of road revealed the bodies of 48 raptors, 26 golden eagles among them. Most of these eagles were juveniles (Ellis et al, 1969).

Causes of juvenile mortality include trichomoniasis, impact injuries, predation, starvation, shooting and electrocution (Kochert, 1972; Boeker and Ray, 1971; Edwards, 1969; Page and Seibert, 1972). Trichomoniasis and starvation are insignificant factors in overall mortality and have no influence on population numbers. Predation would also be insignificant and a natural factor that golden eagle populations have been adapted to for some thousands of years.

Impact injuries appear to be fairly common, particularly among juveniles. Of 60 golden eagles which he has autopsied, Kochert (pers. comm.) has observed that 18.3% have died from impact injuries.

Shooting is one of the major types of human-inflicted mortality. Now that it is illegal to kill golden eagles, and since the major eagle shootoffs of eagles in Texas have stopped, shooting probably functions as a limiting factor only in isolated, local situations, such as the elimination of the resident population in west Texas (Heugly, 1973a). Boeker and Ray (1971) reported that four out of five band returns they received from nestling eagles were from birds that had been shot. Kochert (pers. comm.) reported that 15% of the 60 eagles which he autopsied in Idaho were the victims of shooting. Shooting was also the most frequent cause of mortality reported by Edwards (1969) in his study in Utah.

Electrocution is a major mortality factor in some areas. Fifty-five percent of 60 eagles that Kochert (pers. comm.) autopsied died from electrocution. Edwards (1969) found eight electrocuted eagles under a single pole in Utah. Boeker (1972) reported a loss of 37 eagles under 88 poles of a three-phase

line, 47 eagles under a 12-mile stretch of three-phase line in Utah, and 20 eagles under a similar line in Wyoming. Altogether, Boeker estimated that a minimum of 300 eagles have been electrocuted since 1970.

The Bureau of Land Management conducted a limited survey of known raptor electrocutions on BLM lands, and found that the most serious problems existed in Idaho. Two different power lines accounted for the loss of more than 100 birds of prey, most of them golden eagles. These powerlines were near the birds of prey sanctuary, and the Bureau feels it is essential that these lines be modified (Craig, pers. comm.). The BLM Denver Service Center is now in the process of proposing standards for powerlines going across BLM land (Crawford, 1973).

Electrocution occurs when an eagle makes simultaneous contact between the ground wire and energized parts on a transformer pole, the ground wire and phase conductor in a primary pole, or two phase conductors at a primary pole which are not carrying the same amount of current. Any power transmission line which is constructed so that a bird can make simultaneous contact between the different parts in the combinations described above is a potential hazard.

Three-phase, 4-carrier lines with spacing less than six feet between the phase conductors have been found to be particularly lethal. Another type of line that accounts for a large number of eagle deaths is a secondary line which carries 7240 volts in a single phase conductor attached directly to the pole about three feet above a neutral wire with ground wires acting as lightning arrestors running to the top of each pole. A third design is the flat, horizontal placement of wires on a cross-arm, with two hot wires on each side of the pole placed about three feet apart, with ground wires extending to the tops of the poles (Boeker, 1972).

Powerlines which cross terrain with numerous natural perching sites are little used by birds. However, where natural perching sites are nonexistent or few in number, powerline poles are frequently used because they provide elevated perches offering good visibility and easy take-offs. There is also some evidence available that poles which are situated near or on the crest of hills or ridges which have more favorable air currents are more frequently used than poles in the nearby vicinity (Boeker, 1972).

Most of the electrocuted eagles have been juveniles. Of the 33 electrocuted eagles which Kochert (pers. comm.) examined, 9 were adults and 24 were juveniles. Sixteen of 17 eagles found electrocuted on the Pawnee National Grasslands were juveniles

(Boeker, 1972). Nelson (1973) has been studying the electrocution problem with trained eagles and mockup power poles in Idaho. His films show conclusively that juvenile eagles, particularly recently fledged birds, are extremely awkward flyers and equally awkward in their landing. Their wings frequently touch the fatal points of the transmission lines, ground wires and poles.

In some situations, simple design modifications solve the problem. Suggested methods include the use of low-profile and enclosed transformers, providing a minimum of seven feet of space between phase conductors and ground wires on all lines, setting crossarms at least two or more feet below the top of the pole and hanging insulators under the crossarms, and placing insulators two or more feet from the top and insulating the ground wires. Installation of perches at poles where multiple bird kills have been observed has also been recommended (Boeker, 1972).

An additional detrimental effect of some powerlines is their location next to easily accessible roads and the subsequent shooting of raptors, especially juveniles. Juvenile golden eagles are more tolerant of man than the adults. This lack of wariness often places them within range of firearms and makes them easy targets. They tend to roost in more accessible places, which also increases their vulnerability to shooting (Edwards, 1969).

Reproductive failures of two endangered species, the American peregrine falcon and the southern bald eagle, have been correlated with the organochlorine pesticides to which these birds have been exposed (Snow, 1972, 1973). Autopsies have been conducted to determine if golden eagles are exposed to and accumulating pesticide residues at the rates of some of the other avian species.

Reichel et al (1969) analyzed 21 golden eagles during 1964-1965. Their findings indicated a median of .49 ppm DDE, .05 ppm DDD, .05 ppm DDT, .09 ppm dieldrin and .05 ppm heptachlor epoxide in the eagle carcasses. In 1965, comparative figures for bald eagles were 8.9 ppm DDE, .44 ppm DDD, .20 ppm DDT, .33 ppm dieldrin and .06 ppm heptachlor epoxide.

The residues which Reichel et al found in golden eagles were considerably lower than those present in bald eagles. They advanced the theory that this might reflect differences in food habits. The diet of bald eagles consists mainly of fish, while golden eagles consume mammals. Rates of exposure to pesticides also differed.

Kochert (1972) studied chemical contamination in golden eagles in Idaho. He analyzed eggs, muscle tissue, kidneys and feathers of the eagles, as well as parts of prey species. DDT and DDE were the predominant residues and local variations in contamination were very evident. He found that the mean organochlorine residues in the major golden eagle prey species were much lower than those found in peregrine falcon prey.

No significant differences were observed between residue levels in free-roaming prey shot in agricultural and non-agricultural areas in 1970 and residue levels in jackrabbits taken by eagles. Residue levels in cottontails sampled at eagle eyries appeared to be significantly higher than those which were randomly shot. This indicates that selection by eagles for prey with higher pesticide levels may exist, but further study is needed. Reynolds (1969) observed a similar situation in Montana.

All eggs analyzed by Kochert contained DDE residues which were well below levels thought to induce reproductive failures in other raptorial and fish-eating avian species. No significant differences were found in residue levels of fertile and infertile eggs, nor was there any significance in differences of eggshell thickness in eggs collected in the Idaho study area and eggs collected in the central western United States before 1947. Although all eagles examined by Kochert contained measurable organochlorine residues, these were well below toxic levels.

In his Montana study, Reynolds (1969) noted that pesticide residues in eagle eggs were lower than in the eggs of great horned owls, redtailed hawks and prairie falcons. He speculated on two possible reasons for these differences. Adult eagles in the area were probably not migratory, therefore not exposed to pesticides as frequently as the other three species, which did migrate. Also, the prey of the eagles may have differed sufficiently so that they were taking less contaminated prey.

Seidensticker (1968) conducted a study on the response of juvenile raptors to DDT in the diet, using redtailed hawks and golden eagles in his experiments. DDT residues in experimental hawks were much higher than in the controls, indicating that nestling hawks were unable to completely metabolize or eliminate all the DDT which they were being fed, and it accumulated in their tissues.

Total DDT residues in hawks fed DDT as nestlings, but given food devoid of DDT while in captivity after the nestling period were only one-fourth as high as the residues found in the hawks sacrificed at the end of the nestling period. Once full growth

was achieved, it appeared that captive juvenile redtailed hawks were able to dispose of DDT which they were fed. However, wild hawks do not always eat well and they exercise more than captive birds. Therefore they may be less able to handle DDT loads.

Seidensticker's data also indicated that more DDT accumulated in the tissues of diseased nestlings than in the tissues of healthy nestlings which were sacrificed. No significant differences in growth were noted between control and experimental birds.

Seidensticker found that nestling eagles were similar to nestling redtailed hawks in their inability to metabolize and eliminate all of the DDT which they were experimentally fed. He also noted the presence of DDT residues in the control birds which were not being dosed with pesticides, indicating that organochlorines are being transferred to raptors through natural food.

Kochert (1972) analyzed eagles and prey species for mercury contamination. He found that mercury levels in pheasants were consistently higher than in jackrabbits and cottontails. As the eagles in his area were eating pheasants during the breeding season, this is the probable source of mercury contamination in the eagles.

Twenty-four eagle eggs which were analyzed for mercury had lower levels than the average level in prey which was examined. However, the mean mercury levels in the kidneys of eaglets two to ten weeks old were ten times as concentrated as in the eggs. The concentration in the eaglet kidneys averaged 3.5 times the amount found in the muscle of the prey species.

Kochert noted that feathers are an important excretory route for mercury from the body and could be used to judge the amounts of mercury contamination. Mercury levels from feathers of birds collected prior to 1940 did not differ from the loads detected in feathers in 1971. Mercury concentrations decreased as the nesting season progressed, along with a decrease of pheasants found in the nests.

Kochert showed that the food chain of golden eagles in southwestern Idaho is very short, and jackrabbits are the primary prey item. Since jackrabbits have very low pesticide residues, accumulation of pesticides in the eagles is also low. A tendency to remain resident in the area further reduced exposure to higher levels of chemical contamination.

Lockie et al (1969) conducted studies on the breeding success and organochlorine residues in golden eagles in west Scotland. Earlier data indicated that the greater the quantities of dieldrin present, the poorer the breeding success. Eagles acquired dieldrin residues by consuming carrion in the form of sheep which had been subjected to dieldrin sheep dips.

Twenty-five eyries were examined. During 1963 to 1965, when dieldrin sheep dips were being used, only 31% of these nests fledged young. The mean dieldrin level in the eggs analyzed was .86 ppm. From 1966 to 1968, after dieldrin was banned from sheep dips, 69% of these same nests fledged young and the mean dieldrin level in the eggs had decreased to .34 ppm.

In an earlier study by Lockie and Ratcliffe, it was noted that egg breakage was correlated with amounts of dieldrin exceeding 1 ppm in the eggs. Broken eggs were frequently found from 1963 to 1965, but infrequently after the ban on dieldrin sheep dips went into effect.

Because the decrease in breeding success of golden eagles could have been related to an inadequate food supply, Lockie et al also made a study of food available during this time period. Essentially they found that the amount of carrion and live prey available was more than enough to support the eagles in the area and any competitors of the eagles. Since the food supply was adequate, they concluded that contamination by dieldrin ingested with sheep carrion was involved in a substantial decline in the breeding success of golden eagles in west Scotland and that with a reduction in the amounts of dieldrin present in the environment, breeding success improved significantly.

5. Habitat Requirements

The golden eagle is a resident of mountainous regions, especially in the western part of the United States. In the eastern United States it nested only in the mountains. Breeding records are almost completely lacking from the Great Plains region (Bent, 1937). Material which Olendorff (1973) accumulated in the Pawnee National Grasslands, Colorado, indicates that this is marginal habitat for golden eagles.

Most eagle eyries are located on cliffs, although in some situations tree nests are not uncommon. Nests may be located on the ground and on cliffs as high as 400 feet (Beecham, 1970; Kochert, 1972; Carnie, 1954; Campbell, 1960; Camenzind, 1968, 1969; Bent, 1937; Page and Seibert, 1972; Brown and Amadon, 1968; Kalmbach et al, 1964). Tree nests have been located in

Douglas fir, cottonwood, ponderosa pine, sycamores, eucalyptus, redwoods, oaks and dead snags (McGahan, 1966; Bent, 1937). The height of tree nests may vary from 10 to 100 feet above the ground (Bent, 1937).

Elevations of active eyries have been recorded at 5000 to 8500 feet in Elko County, Nevada (Page and Seibert, 1973), 4000 to 7000 feet in Montana (McGahan, 1968), 4750 to 8500 feet in Utah (Murphy, 1973a), 3900 feet in Brooks Range, Alaska (Campbell, 1960), 2300 to 5000 feet in Idaho (Kochert, 1972) and 4000 to 10,000 feet in Colorado, New Mexico and Wyoming (Boeker and Ray, 1971).

Golden eagle nests are constructed of sticks up to two inches in diameter, which are firmly interwoven with smaller sticks, twigs, brush, roots, grass, leaves and miscellaneous items such as deer antlers. The nest cup, which holds the eggs and the young eaglets, has a lining of grasses, weeds, dead and green leaves, soft mosses and lichens. Greenery such as cottonwood and conifer branches are usually added. The reasons for this are not known. Cliff sites chosen for nests tend to be relatively inaccessible, although some nests can be easily reached (Bent, 1937; Kalmbach et al, 1964; Brown and Amadon, 1968).

Eagle eyries generally can be seen some distance away, appearing as dark objects on shelves or ledges on cliff faces. In most instances, a patch of whitewash from excretion is also visible. This characteristic is particularly useful for spotting eagle nests from the air (D'Ostilio, 1954; Page and Seibert, 1972). In Alaska, the rock surrounding an eagle nest may be covered with an orange foliose lichen, which is useful in detecting eyries (Murie, 1944). Many nests are protected by overhangs and are on cliffs which permit an extensive view of the surrounding countryside (Bent, 1937; D'Ostilio, 1954).

The size of the nest is dependent on the location and how many years it has been used. A nest that Campbell (1960) observed in the Brooks Range had very little nesting material. Brown and Amadon (1968) indicate that nests may become eight to ten feet across and three to four feet thick and more. Tree nests tend to be deeper and more massive. Brown and Amadon (1968) report that the largest tree nest recorded for golden eagles was 17 feet deep and four feet across.

The direction of exposure of the nest to the sun has been recorded by a number of observers. In some instances, a significance is attached to the exposure of the nest, and others feel it is merely a random happenstance (Kalmbach et al, 1964).

In Utah, Hinman (1960) noted that the nest sites he located generally faced southeast, south, southwest or west. In Camenzind's Utah study (1968, 1969), 55.5% of the nests faced west, 22.2% faced north, 18.6% faced south and 3.7% faced east. In Montana, McGahan (1966, 1968) found 50% of the nests faced south, 23% faced east, 18% faced west, and 9% faced north. In Nevada, Page and Seibert (1972) reported that 43% of the nests they located faced east, 24% faced south, 21% faced west and 12% faced north.

McGahan (1968) felt that nest site preference was influenced by the direction of the sun's rays. He felt that exposure was especially important during the early spring months, especially for the incubating adults and the eggs, because the temperatures were often below freezing. In June and July, when temperatures were considerably warmer, nest sites facing south and east would be advantageous because they would receive the warm morning sun but be shaded in the afternoon.

Page and Seibert (1972) also felt that nest exposure was of some importance. Since the average daily temperature was higher in the Nevada study area than in Montana, eastern-facing sites would appear to be preferable. Kochert (1972) observed eight eaglets, four to eight weeks old, that probably died from heat prostration. Five of them died shortly after prolonged periods of temperature near 90° F. All of them were in nests which faced a western or southern direction and were fully exposed to direct sunlight during the afternoon. Kochert (1973c) observed that when certain pairs nest in northern and eastern exposed nests they consistently raise young, but when the same pairs use alternate nests with a southern or western exposure, the young usually die.

There does not appear to be any consistency in the use of alternate nests. Some breeding pairs seem to use alternate nests in alternate years, others never use alternates, even though they spend time repairing all of their nests, and birds which are unsuccessful in their nesting attempt at one nest may use another nest the following year. Individual behavior of eagles seems to be a major determining factor in nest usage (Boeker and Ray, 1971).

Camenzind (1969) found that the distance between alternate nests in Utah varied from less than 25 yards to 1.3 miles. McGahan (1966) noted that alternate nests in Montana were several feet to 3.8 miles apart. Distances between active eyries were observed by McGahan (1968) in Montana to be a minimum of 1.2 miles and a maximum of 10.5 miles. Camenzind (1969) in Utah found two active eyries which were only .7 mile

apart. The maximum distance he noted was 16.1 miles. In Kochert's study in Idaho (1972), distance between 56 active eyries ranged from .5 to 10.0 miles and averaged 2.7 miles.

Although figures are often given for nesting densities of pairs of eagles per so many square miles, there seems to be little data on delineation of actual territories. Reynolds (1969) attempted to determine the territory of one pair of eagles in Montana and learned that they spent most of their time in a 13-square-mile area, but overall used 32 square miles during a time period when the density of breeding pairs was one pair per 54.8 square miles to one pair per 105 square miles. Smith and Murphy (1973) found that golden eagles on their study area maintained average home ranges of 9.02 square miles.

In some situations there appears to be some overlap of hunting territory and golden eagles apparently do not expend much effort in defending anything beyond their nesting area. Kochert (1972) has noted that in some instances in Idaho, nesting areas may be separate from hunting areas.

It is difficult to determine just how much freedom from human interference is required by eagles for continued occupation of their territory. As with peregrine falcons and bald eagles, the tolerances of individual eagles must be considered. Apparently some pairs will successfully raise young while exposed to a lot of human activity, whereas others will desert. Yet some pairs nesting in remote sites may be highly unsuccessful in their nesting attempts (Kochert, 1972).

Most golden eagles are not too tolerant of extensive human activity. Murphy (1973a) has indicated the abandonment of many traditional eyries and the movement up to higher elevations by golden eagles in Utah. Boeker and Ray (1971) have indicated that many eyries in the Front Range of the Rocky Mountains have been abandoned because of human interference. Although the population as a whole is presently reproductively healthy, it is not inconceivable that human pressure through land and resource development and increased public use of eagle habitat could be a serious stress factor which might result in reduced numbers of golden eagles.

6. Protective Measures Instituted

a. Legal or Regulatory

1. On April 1, 1963, the golden eagle was included in the Bald Eagle Act which had been passed in 1940. Part 11, Title 50, Code of Federal Regulations was revised to give the golden eagle essentially the

same protection which the bald eagle had been given. The exception was that the governors of the states could request permission to take golden eagles seasonally to protect livestock without needing a permit to take a golden eagle at any time, but were permitted to do so in any area of the state and for any period which was determined necessary to protect livestock. Golden eagles could not be taken from aircraft or by the use of poisons. Permits could be issued for scientific purposes and for the religious purposes of Indian tribes.

2. On February 8, 1972, the President of the United States issued an Executive Order banning the use of poisons on public lands.

b. Captive Rearing

1. Frances Hamerstrom and James Grier were successful in artificially inseminating a female golden eagle in 1972. However, there have not been large scale programs for artificial propagation of golden eagles.

2. Erhardt (1971) reported on a pair of golden eagles which produced infertile eggs. Kish (1970) recorded an instance where a pair of eagles at the Topeka Zoo also produced infertile eggs. He concluded that they will reproduce in captivity when given a balanced diet, reasonable space, a nesting facility and material and a buffer zone to reduce disturbances.

3. Thacker (1971) has estimated that there are 173 golden eagles in zoos and another 24 in research projects.

c. Habitat Protection and Improvement

In 1971, the Bureau of Land Management established the Snake River Birds of Prey Natural Area in Idaho. This area exhibits a unique concentration of nesting raptors, including golden eagles, prairie falcons, kestrels and barn owls. Over 100 pairs of prairie falcons have been located (Ogden, 1973). Kochert (1972) observed 12 pairs of golden eagles nesting in the Area in 1971 (Kochert, 1973b).

Procedures are being developed to prohibit desert land entry development within ¼ mile of an eagle eyrie or the canyon rim. The possible impact of desert entry

development on raptor hunting areas is also being studied, as large tracts of monocultural habitat can be detrimental to prey species. Farming in some instances has exterminated populations of Townsend's ground squirrels, which are a staple food item for prairie falcons living in the canyon (Kochert, pers. comm.).

d. Reintroduction

There are no known attempts at reintroduction of golden eagles into formerly occupied territory. However, Nelson (1969) has worked out a procedure which could be used for reintroduction techniques. This involves locating a large number of active eyries which have hatched two or more young. He suggested that three pairs of juvenile goldens would be a maneuverable number to work with. Three males and three females should always be left in the nest. Eyries which have not been used for some time should be selected as the eventual release sites for the eaglets. As much natural food as possible should be fed to the eaglets at the selected nest sites without them realizing that human beings are providing it. When the birds fledge from their eyries, they would require surveillance and a food supply for at least two years. A steady supply of food would probably eliminate migration or movements from the territory. It might also attract wild eagles to bolster the population in the area. Films could be made of these endeavors and visitor centers with spotting scopes could be established in some instances to encourage public interest in eagles.

7. Species and Habitat Management Recommendations

1. Available evidence indicates that golden eagles most frequently and readily desert their nests during the period of incubation. Once the eaglets have hatched, the probability of desertion decreases considerably. However, undue harassment may cause them to desert even fledglings. Human activity should be restricted in areas of known concentrations of golden eagles, such as the Snake River Birds of Prey Natural Area, Idaho, from the time the eagles start incubating their eggs until the eaglets are two weeks old. It is unlikely that the adults would desert the nests and young after that. This time period should extend from February 1 through June 1.

2. Kochert (pers. comm.) has found that adult eagles tolerate activity in the Snake River Canyon below the nests, but are very intolerant of human activity on the canyon rim above them. He feels that, particularly during the early nesting season, activity on the canyon rim should be reduced to a minimum.

3. Golden eagles are very easy targets for shooters. Legal protection is of no avail if the individuals doing the shooting are unaware of this protection or are of such a state of mind that they will shoot eagles anyway. The Snake River Canyon presents the unique situation of many opportunities to shoot eagles and falcons. As an attempt to circumvent the temptation these birds may present as targets, shooting should be prohibited in the Natural Area from February 1 to September 1 (Kochert, pers. comm.).

4. Any proposed or current development of BLM administered lands, whether private or public, should be studied for the possible impact on golden eagle populations. In some instances, human activity in an area where golden eagles nest or hunt will be sufficient to cause them to desert even if harassment is not deliberate. Although eyries may not be disturbed, hunting territory may be disrupted and prey populations reduced, which may have adverse effects on eagles. The impact of programs such as Desert Land Entry Development should be evaluated carefully before permits are given, particularly around the Snake River Birds of Prey Natural Area. Some of the present development goes right up to the canyon rim. Development of large monotypic areas is probably reducing the number of prey available to the raptors living in the canyon, who do much of their hunting on the north canyon rim and adjacent areas. Kochert (pers. comm.) has noted instances where such farming has eliminated ground squirrels from an area.

5. Further studies are needed to determine the food requirements of golden eagles and the populations of prey which must be present to support them and their competitors. Olendorff (1973) has some information indicating that raptors remove relatively little of the total available prey biomass, but mammalian predators and their impact on prey biomass must also be studied to be able to arrive at a point where it can be said with relative certainty that X number of prey species in Y and Z habitats are required to support a population of A predators.

6. Powerlines crossing BLM land should be surveyed to locate problem areas where golden eagles are being electrocuted. Since the eagles and other raptors tend to use power poles in areas where natural perches are lacking, these areas should be surveyed first. When such problem areas are located, the design of the powerlines should be altered to prevent further electrocutions. Since an electrocuted eagle frequently causes an interruption in transmission, such alterations should also be beneficial to the power companies by reducing the time they need to repair such power outages. New powerlines should be constructed according to specifications which eliminate electrocutions.

7. Eyrie sites, with possibly a few exceptions, should not be made known to the general public. Many people are not aware that golden eagles are protected by law and should not be taken into captivity. Downy eaglets present a great temptation to people who do not realize how rapidly the eaglet will grow up or have no idea how to care for them. The other extreme is the unthinking shooter who only sees a living target or is under the impression that the only good eagle is a dead eagle. A third segment of the population consists of those individuals who only want to look at the eagles, but have no comprehension of how to take precautions against desertion by the adults, premature leaping from the nest by the young, or the possibility of an experienced mammalian predator following the human scent trail to an accessible nest and defenseless young.

8. Ongoing Research Projects

1. Michael N. Kochert, Raptor Biologist for the Bureau of Land Management, is studying golden eagles in the Snake River Birds of Prey Natural Area in Idaho. His basic research at present is the responses of golden eagles in relation to changes in their food supply. Along with an extensive quantitative food habits study, radios will be attached to breeding birds to attempt to determine where they hunt in relation to the canyon. Cooperative research efforts are presently being planned to study the major prey species in this area, including habitat requirements, life history, density and distribution. He will be continuing his long-term surveillance of the reproductive performance of breeding birds in southwestern Idaho (Kochert, pers. comm.).

2. David H. Ellis of the Montana Cooperative Wildlife Research Unit has been studying the nesting behavior of the golden eagle. The purpose of his study is to describe, quantify and graphically illustrate the behavior of adult and juvenile golden eagles for the full nesting season. Male-female differences both in parents and nestlings will be identified when possible. The title of his thesis, which will be available in August, 1973, is "Ontogeny of behaviors in nestling golden eagles." (Ellis, pers. comm.)

3. Dr. John Craighead, Leader of the Montana Cooperative Wildlife Research Unit, is keeping four mature golden eagles in captivity, feeding them natural diets, providing them with room to fly within their enclosures and also training them so that they can be flown free in an attempt to get them to breed in captivity (Schwarz, pers. comm.).

4. Alan Harmata at Colorado State University is planning an investigation of golden eagle fledgling mortality, dispersal and behavior on the Pawnee National Grasslands and immediate adjacent areas. Data will be collected through biotelemetric techniques and banding returns. Adult-young interactions, influence of hatching date on fledging success, influence of availability of prey and nest disturbance will also be investigated (Harmata, pers. comm.).

5. Leo Heugly is studying golden eagle-sheep interactions at Brigham Young University (Murphy, pers. comm.).

6. James Mosher at Brigham Young University is conducting a raptor inventory for the Uinta National Forest which will have a major emphasis on golden eagles, including possible study of the energetics of size dimorphism between males and females (Murphy, personal communication; Mosher, personal communication).

7. Dr. Joseph R. Murphy at Brigham Young University is maintaining the long-term surveillance of the golden eagles nesting in the central Utah valleys. In cooperation with personnel of the Bureau of Land Management, the Forest Service and the Utah Division of Wildlife Resources, he is conducting surveys of the status of golden eagle populations throughout the state, with emphasis on management problems related to human disturbances (Murphy, pers. comm.).

9. Summary

The golden eagle is primarily a bird of mountainous country and in the United States is found mainly in the West. Recent estimates suggest a population of 35,000 golden eagles in the contiguous 48 states, with a possible overall population of 50,000 to 100,000 for North America.

The golden eagle is an avian predator with a wingspan ranging from six to seven and one-half feet and a weight of eight to twelve pounds. The maximum weight it is capable of carrying for any distance under favorable conditions is seven pounds. Most of the prey that an eagle normally carries weighs around two pounds.

Food habit studies have shown that rabbits and rodents, which compete with livestock for forage, are the major prey of golden eagles, with as much as 80% to 97% of the food items consisting of these species. Up to 60% of their diet may consist of carrion during certain times of the year.

While golden eagles are capable of killing large game animals and livestock, actual verified cases of such predation are comparatively rare. In many instances, the animals were already dead when the eagles were observed eating them. Although predation on lambs and kids does occur, indications are that the problems are local in nature and not universal.

A female eagle usually lays a clutch of two eggs after a courtship that varies in length from weeks to months. The time of egglaying is dependent on the latitude and may be as early as February in the southwest or as late as June in Alaska. Some eagles may nest every year, while others nest only in alternate years.

Although in many cases both eggs in a clutch will hatch, the overall fledging success is approximately one eaglet per pair or less. Since the mortality of juvenile golden eagles has been estimated to be as high as 75%, it may take one pair of eagles eight to ten years to produce two birds just to replace themselves.

Most golden eagle eyries are located on cliffs, but trees may also be used. Eagles frequently have alternate nests, numbering from one to fourteen. If one mate is killed, the survivor seems to readily acquire a new mate and the site is used in that same season if the mate is replaced early enough. If both birds of a pair are killed, the site may be occupied by a new pair the following year.

Densities of golden eagle pairs have varied from one pair per 25 square miles in southwestern Idaho, which is excellent eagle habitat, to one pair per 200 square miles in the Pawnee National Grasslands, Colorado, which is marginal eagle habitat. Many other studies have determined densities to range from 40 to 75 square miles per pair.

Human disturbance has accounted for 85% of the nest desertions observed on the Front Range of the Rocky Mountains in Colorado and New Mexico. The amount of human-caused pressure that eagles will tolerate is influenced by the adaptability of individuals. Although some eagles will successfully raise young in areas where there is a lot of human activity, most birds are not that tolerant.

The golden eagle is protected by the same laws that protect the bald eagle. The exception has been that the governors of affected states could request blanket permits from the Secretary of the Interior to allow the killing of eagles during the period of lambing and kidding without a special permit having to be issued for each eagle to be taken ostensibly for control purposes. Recently, such permits have not been issued. The Presidential Executive Order banning the use of poisons on public lands is also beneficial to eagles.

In 1971, the Bureau of Land Management established the Snake River Birds of Prey Natural Area in Idaho. This particular area has a unique concentration of nesting raptors, with 12 pairs of golden eagles and more than 100 pairs of prairie falcons. The birds are afforded protection from undue human activity only in the canyon itself. Currently, the prime hunting grounds of these raptors are being threatened by proposed total development of the north rim of the canyon in the desert land entry program. Attempts are presently being made by the Bureau of Land Management to establish a buffer zone.

Loss of habitat appears to be the most serious threat to the continued existence of golden eagles. Although human-inflicted mortality is common in some areas, the population is reproductively sound, and chemical contamination is not presently a problem. However, increasing demands for use of our public lands may have detrimental effects on golden eagles and their habitat. Wise use and management of our lands should avert that problem.

10. Authorities

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11. Governmental, Private and International Organizations Actively Involved With This Species' Welfare

A. 1. National Audubon Society
950 Third Avenue
New York, New York 10022

2. The major objective of the National Audubon Society is to advance public understanding of our wildlife, its habitat, and all natural resources, and the relationship of wise use and intelligent treatment to human progress.

3. Alexander Sprunt, IV, Research Director

4. National Audubon has a series of leaflets and charts on birds of prey and has concentrated its efforts for raptors in the area of education and protective legislation. This organization sponsored "The Eagle and the Hawk," a television special on injured raptors and golden eagles. The Society provided funds for Edward's study on bald and golden eagles in Utah, has been one of the groups pressuring for the abatement of electrocution problems, and was one of the groups instrumental in the designation of the Snake River Birds of Prey Natural Area in Idaho.

B. 1. Raptor Research Foundation, Inc.
c/o Byron E. Harrell
University of South Dakota
Vermillion, South Dakota 57609

2. The main purpose of the Raptor Research Foundation is to stimulate, coordinate, direct and conduct research in the biology and management of birds of prey, and to promote a better understanding and appreciation of the value of these birds.

3. Byron E. Harrell
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4. The Raptor Research Foundation publishes "Raptor Research," which often contains information on golden eagles. The Foundation was one of the sponsors of the Conference on Raptor Conservation Techniques, Colorado State University, Fort Collins, Colorado, March 22-24, 1973, and will be publishing the proceedings of that conference.

C. 1. Bureau of Land Management
Washington, D. C. 20240

2. The BLM administers approximately sixty percent of the Federally owned lands which are located primarily in the western states. These lands are managed under multiple-use principles, including outdoor recreation, fish and wildlife production, livestock grazing, timber, industrial development, watershed protection and mineral production.

3. Robert J. Smith, Chief, Division of Wildlife

4. The Bureau of Land Management is responsible for habitat management on the Snake River Birds of Prey Natural Area in Idaho. The biologist directly working on management plans is Michael N. Kochert, Boise District, Bureau of Land Management, 230 Collins Road, Boise, Idaho, 83702. BLM is also proposing standards for the establishment and maintenance of power lines across BLM lands.

LITERATURE CITED

Alford, John R., III and Eric G. Bolen. 1972. A note on golden eagle talon wounds. Wilson Bulletin 84(4):487-489.

American Ornithologists Union. 1957. The A.O.U. Checklist of North American Birds. The Lord Baltimore Press, Baltimore, Maryland. p. 112.

Arnell, W. Bruce. 1971. Prey utilization by nesting golden eagles (Aquila chrysaetos) in central Utah. M.S. thesis. Brigham Young University, Provo, Utah. 53 p.

Beecham, John J. 1970. Nesting ecology of the golden eagle in southwestern Idaho. M.S. thesis. University of Idaho, Moscow. 48 p.

Bent, Arthur C. 1937. Life Histories of North American Birds of Prey. Order Falconiformes (Part 1). Smithsonian Institution. U. S. National Museum. Bulletin 167. 409 p.

Boeker, Erwin L. 1972. Powerlines and bird electrocutions. U. S. Dept. of the Interior, Bureau of Sport Fisheries and Wildlife. Unpublished. 8 p.

_____ and Thomas D. Ray. 1971. Golden eagle population studies in the Southwest. Condor 73(4):463-467.

Brown, Leslie H. and Adam Watson. 1964. The golden eagle in relation to its food supply. Ibis 106(1):78-100.

_____ and Dean Amadon. 1968. Eagles, Hawks and Falcons of the World. McGraw-Hill Book Company, New York. p. 663-664, 666-669.

Bruns, Eldon H. 1970. Winter predation of golden eagles and coyotes on pronghorn antelope. Canadian Field Naturalist 84(3):301-304.

Camenzind, Franz J. 1968. Nesting ecology and behavior of the golden eagle in west central Utah. M.S. thesis. Brigham Young University, Provo. 49 p.

_____. 1969. Nesting ecology and behavior of the golden eagle, Aquila chrysaetos L. Brigham Young University Science Bulletin, Biological Series, 10(4):4-15.

Campbell, John M. 1960. Nesting of the golden eagle in the central Brooks Range of Arctic Alaska. Condor 62(4):298.

Carnie, S. Kent. 1954. Food habits of nesting golden eagles in the coast ranges of California. Condor 56(1):3-12.

Crawford, John. 1973. Powerline standards to reduce raptor losses on the natural resource lands. In prep.

Dixon, James B. 1937. The golden eagle in San Diego County, California. Condor 39(2):49-56.

D'Ostilio, Dominick O. 1954. Nesting status and food of the golden eagle in northern Colorado. M.S. thesis. University of Colorado, Boulder. 48 p.

Edwards, Clyde C. 1969. Winter behavior and population dynamics of American eagles in Utah. Ph.D. thesis. Brigham Young University, Provo, Utah. 156 p. Photos.

Ellis, David H., D. G. Smith and J. R. Murphy. 1969. Studies on raptor mortality in western Utah. Great Basin Naturalist 29(3):165-167.

Fevold, H. R. and John J. Craighead. 1958. Food requirements of the golden eagle. Auk 75(3):312-317.

Ford, Homer S. and J. S. Alcorn. 1964. Observations of golden eagle attacks on coyotes. Condor 66(1):76-77.

Gessaman, James A. 1973. Is heart rate a good measure of the energy metabolism of the semi-free-living kestrel? In prep.

Grossman, Mary L. and John Hamlet. 1964. Birds of Prey of the World. Clarkson N. Porter, New York. p. 314-315.

Gullion, Gordon W. 1957. Two records of unprovoked attack by golden eagles. Condor 59(3):210-211.

Heugly, Leo G. 1973a. Trends of golden eagle numbers in the western United States. In prep.

_____. 1973b. Golden eagle-domestic sheep interaction in Utah. In prep.

Hinman, Robert A. 1960. Antelope populations in southwestern Utah, with special reference to golden eagle predation. M.S. thesis. Utah State University, Logan. 66 p.

Hobbie, John E. and Tom Cade. 1962. Observations on the breeding of golden eagles at Lake Peters in northern Alaska. Auk 64(3):235-237.

Huey, Laurence M. 1962. Comparison of the weight-lifting capacities of a house finch and a golden eagle. Auk 79(3): 485.

Jollie, Malcolm T. 1943. The golden eagle: its life history, behavior and ecology. M.S. thesis. University of Colorado, Boulder. 227 p.

_____. 1947. Plumage changes in the golden eagle. Auk 64(4):549-576.

Kalmbach, E. R., R. H. Imler and L. W. Arnold. 1964. The American Eagles and Their Economic Status. U. S. Dept. of Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. Washington, D. C. 86 p.

Kelleher, James V. and William F. O'Malia. 1971. Golden eagle attacks a mallard. Auk 88:186.

Kish, Frank. 1970. Egg laying and incubation by American golden eagles (Aquila chrysaetos canadensis) at Topeka Zoo. International Zoo Yearbook 10:26-29.

Kochert, Michael N. 1972. Population status and chemical contamination in golden eagles in southwestern Idaho. M.S. thesis. University of Idaho, Moscow. 115 p.

_____. 1973a. Effects of organochlorines and mercury on southwestern Idaho golden eagles. In prep.

_____. 1973b. The Bureau of Land Management and raptor management in Idaho. In prep.

_____. 1973c. Golden eagle critique. Available at Conservation Library, Denver Public Library.

Lehti, R. W. 1947. The golden eagle attacking antelope. Jour. Wildlife Management 11(4):348-349.

Lockie, J. D. and D. Stephen. 1959. Eagles, lambs and land management on Lewis. J. Animal Ecology. 28(1):43-50.

_____, D. A. Ratcliffe and R. Balharry. 1969. Breeding success and organochlorine residues in golden eagles in west Scotland. Jour. of Applied Ecology 6:381-389.

McGahan, Jerry. 1966. Ecology of the golden eagle. M.A. thesis. University of Montana, Missoula. 78 p.

_____. 1967. Quantified estimates of predation by a golden eagle population. Jour. of Wildlife Management 31(3):496-501.

_____. 1968. Ecology of the golden eagle. Auk 85(1): 1-12.

Mollhagen, Tony R., R. W. Wiley and R. L. Packard. 1972. Prey remains in golden eagle nests: Texas and New Mexico. Jour. of Wildlife Management 36(3):784-792.

Mosher, J. A. 1973. The energetics of size dimorphism. In prep.

Murie, Adolph. 1944. The Wolves of Mt. McKinley. Fauna of the National Parks of the United States. Fauna Series No. 5. National Park Service. Washington, D. C. p. 222-229.

Murphy, Joseph R. 1973a. Status of a nesting golden eagle population in central Utah. In prep.

_____. 1973b. Golden eagle critique. Available at Conservation Library, Denver Public Library.

Nelson, Morlan W. 1962. Hunting characteristics of eagles. Interstate Antelope Conference 1962, Transactions: 96-99.

_____. 1969. Research needs in reestablishing local raptorial bird populations. In: Peregrine Falcon Populations, Their Biology and Decline. Ed. J. J. Hickey. University of Wisconsin Press, Madison. p. 403-407.

_____. 1973. The problem of electrocution of eagles on powerlines. In prep.

Olendorff, Richard R. 1973. The ecology of the nesting birds of prey of northeastern Colorado. U. S. International Biological Program. Technical Report No. 211. Natural Resources Ecology Laboratory, Colorado State University, Fort Collins, Colorado. 233 p.

Page, Jerry L. and D. J. Seibert. 1973. Inventory of golden eagle nests in Elko County, Nevada. Unpublished manuscript. Bureau of Land Management and Bureau of Sport Fisheries and Wildlife. 16 p.

Reichel, W. L., E. Cromartie, T. G. Lamont, B. M. Mulhern and R. M. Prouty. 1969. Pesticide residues in eagles. Pesticides Monitoring Journal 3(3):142-144.

Reynolds, Harry V. III. 1969. Population status of the golden eagle in southcentral Montana. M. S. thesis. University of Montana, Missoula. 61 p.

Robards, F. C. 1973. Bald eagle critique. Available at the Conservation Library, Denver Public Library.

Seidensticker, John C., IV. 1968. Response of juvenile raptors to DDT in the diet. M. S. thesis. University of Montana, Missoula. 82 p.

Smith, Dwight G. and J. R. Murphy. 1973. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young Univ. Sci. Bull. (Biol. Series) 18(3). In prep.

Snow, Carol. 1972. American Peregrine Falcon (Falco peregrinus anatum) and Arctic peregrine falcon (Falcon peregrinus tundrius). Habitat Management Series for Endangered Species. Report No. 1. Bureau of Land Management, Portland, Oregon. 35 p.

_____. 1973. Southern bald eagle (Haliaeetus leucocephalus leucocephalus) and northern bald eagle (Haliaeetus leucocephalus alascanus). Habitat Management Series for Endangered Species. Report No. 5. Bureau of Land Management, Portland, Oregon. 58 p.

Sperry, Charles C. 1957. Golden eagle attacks decoy duck. Wilson Bulletin 69(1):107-108.

Spofford, Walter R. 1964a. The golden eagle in the Trans-Pecos and Edwards Plateau of Texas. Audubon Conservation Report No. 1. National Audubon Society, New York. 47 p.

_____1964b. Recommendations for conservation and control of the golden eagle. Audubon 66(1):46-47.

_____. 1971. Breeding status of the golden eagle in the Appalachians. American Birds 25:3-7.

Sprunt, Alexander. 1973. Bald eagle critique. Available at the Conservation Library, Denver Public Library.

Sumner, E. L., Jr. 1929. Notes on the growth and behavior of young golden eagles. Auk 46(2):161-169.

Thacker, Roger. 1971. Estimations relative to birds of prey in captivity in the United States of America. Raptor Research News 5(4):108-122.

Walker, Lewis and Marian Walker. 1940. Headlines on eagles. Nature Magazine 33(6):320-323.

Wiley, Robert W. and Eric Bolen. 1971. Eagle-livestock relationships: livestock carcass census and wound characteristics. Southwestern Naturalist 16(2):151-169. Photos.

Willard, F. C. 1916. Notes on the golden eagle in Arizona. Condor 18(5):200-201.

Wood, Dale T. 1946. Eye-witness account of golden eagle killing calf. Condor 48(3):143.

Woodgerd, Wesley. 1952. Food habits of the golden eagle. Jour. of Wildlife Management 16(4):457-459.

Wrakestraw, George F. 1972. Wyoming bald and golden eagle survey, 1972. Federal Aid in Fish and Wildlife Restoration. Wyoming W-50-R-21, Project objective No. 7, Job No. 31. 7 p. Unpublished.

ADDITIONAL REFERENCES

Glover, Fred A. and Leo G. Heugly. 1970. Golden eagle ecology in west Texas. Final report to National Audubon Society. Colorado Cooperative Wildlife Research Unit, Fort Collins. 84 p.

Olendorff, Richard R. and Sharon E. Olendorff. 1968. An Extensive Bibliography on Falconry, Eagles, Hawks, Falcons and Other Diurnal Birds of Prey. Part 1. Falconry and Eagles. Published by R. R. Olendorff. 78 p.

Orent, Sander and J. William Levinson. 1971. Considerations of domestic sheep mortality in northwestern Colorado. Unpublished manuscript. Colorado State University, Fort Collins. 57 p.

Smith, Dwight G. and J. R. Murphy. 1972. Unusual causes of raptor mortality. Raptor Research 6(1):4-5.

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